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HYDRO-ELECTRIC TURBINE PROJECT

Prepared for

MONTANA DEPAPTMENT of NATURAL RESOURCES and CONSERVATION

HYDRO-ELECTRIC TURBINE PROJECT

Prepared by

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I. Objective:

We installed a Peltech (hybrid pelton) water turbine, manufactured by Small Hydroelectric systems and Equipment (hereafter called S.H.S.E.). This was put on a 50 foot head with a 3.4-9 c.f.s. flow. The pipeline is 1520 feet of 80 psi PVC. It has gasketed joints. Our purpose was to utilize our year around irrigation drain water to supply our farms electric needs. We also went induction and plan to sell the excess to our rural electric (R.E.A.). We believe that hydro power has such potential in this state and our community and that it could be as easily developed as coal or nuclear and cheaper also.

We wanted a turbine that would deliver the most power for our money and would be relatively maintenance free also. Our objectives have not yet been reached as we have only ½ of the kilowatts that we were guaranteed. We have stimulated an interest in our area for hydro power as well as from all over the state.

II. PROJECT IMPLEMENTATION:

1. Project Planning and Equipment Aquisition;

There was very little information out on low head hydro turbines and their application when I started gathering information (1978). I wrote to all the turbine companies in this country as well as Canada, Sweden, England, and Germany (see exhibit A). I talked with several turbine consultanting firms. These were Childs and Associates and Red Wheel Waterworks. All the companies and people listed in this report will be listed in exhibit A. There was no one who could say which system was most appropriate for my application at this time. Each one seemed biased by what they sold. I talked with Darrell Gordon, head of the G.E. Hydro division on the results of their tests on pelton wheels. He said that the original pelton wheel was most efficient on heads of 100 ft. and up. Independent Power Developers, in Noxon, were the only turbine manufacturers in the state. We visited them and they only tried to discourage us. Later we heard only bad reports of their business practices. Many turbine dealers took two years to get us a bid and the type of turbines they had. I obtained two bids after I had already ordered the equipment. One of these I would have considered in my final choice if it had been earlier.

I narrowed it down to a hybrid pelton and a crossflow. But, due to the high cost and low efficiency of the crossflow, we went with the pelton from S.H.S.E. They were very helpful at putting us in contact with different companies and people that deal with hydro equipment. Several good books on hydro are, "Successful Alternate Energy Methods" by James Ritchie, Structure Pub. co., Box 1002, Farmington Mi. 48024. and "Water Power for Home Energy" Dermot McGiugan, Garden Way Pub. Co., Charlotte, Vermont 05445. The A.R.E.O. office in Billings also had some helpful publcations.

The efficiency of our pelton was rated from 83%-88%. It was tested by G.E. and received an 85% rating for efficiency. We were guaranteed 21 K.W. from S.H.S.E. and this was the highest K.W. that we could find at the time. The bids I received were as follows:
G.E. Hydro; crossflow, complete package $50,000, 60-70% efficient, 12 K.W.
S.H.S.E.: hybrid pelton, turbine alone, $7,600, 83-88% efficient, 21 K.W.
Leroy Somer; propeller type, complete package $20,328, 70% efficient, 15-19 K.W. at 7 c.f.s.
Canyon Industries; crossflow, turbine alone, $4,882, 10 K.W.
Ossberger; crossflow, turbine alone, $29,000, 60% effecient, 8-10 K.W.
Red Wheel Waterworks suggested a turgo wheel from England. They were over $25,000 and had no output ratings. Our engineer, Jerry Nypen, and the D.N.R.C. could give us no recommendations on which system was the best, because information was so scarce on small hydro. After the turbine was selected we had to find an electrical system that would be compatible with the turbine. S.H.S.E. recommended Energy Equipment and Short Stoppers Electric as they

had worked with S.H.S.E before. Energy Equipment, was selected because they were going to come out and educate the R.E.A. on induction and come again with an engineer to make the interconnection with the R.E.A. grid. Their bid was, $4,000 for the panel and $1,219.80 for a Lois Allis 1840 rpm induction generator. The control panel was subed out to C.E.M.C.O. (now Transelectro) of Seattle. This was to be the first induction system on our rural electrics lines. They didn't even know what to require for safequards. This made it very difficult for us to come up with plans for the electical system and caused us six months delay. Jerry Torgeson, one of the R,E,A,s electrical engineers was put in charge of our project and has become very knowledgable on induction. He had only a few systems to draw from in the whole U.S. They were larger systems than ours and required many safety features. All of which ours had to have. The R.E.A. is very satisfied with the safety of our equipment. This we felt was very important as we would be in a lifetime contract with them. Our contract with them is included as exhibit B.

2.. SYSTEM INSTALLATION:

I will divide the work into five stages;

A. Pipeline: July 25-Aug.1, 1981, 700 ft. laid
Nov. 10- Nov. 16, 1981, 820 ft. laid.
The last 820 ft. was left open till spring so that concrete collars could be put over the joints as it was on a slope. The labor was done by seven men for 50 hours and Rick, for 100 hours as he did the backfilling and made the collars. Installations were made by;
Greenfield Irrigation District-backhoeing trench
Engineer-Jerry Nypen-surveying and supervising
Family and friends laid the pipe
Rick-backfilling with our cat and backhoe (20 hours)

We installed a pressure relief pipe at the headworks and a stand pipe 700 ft. into the pipeline that stands 7 ft. tall. If we shut a valve to fast at the turbine, the pressure forces water up the pipe.

B. Headworks: July 26- July 28, 1981
The labor was done by Rick and two others. A waterman 15 inch turnout was bolted to this. Pictures are being included so you can better visualize our system. They are in exhibit C. We had to wait for a slack period in the irrigation season to do the digging and cement work. No trashrack was installed at this time as we thought we might be able to avoid having to put one in.

C. Concrete: June 22-July 3, 1981
It took the Greenfield Irrigation District 2 hrs. for backhoeing. It took Augustine Concrete, 36 hrs. to set the forms and pour the concrete. It took Rick, 40 hours hauling gravel, backhoeing and getting supplies. We had the help of three neighbors for 8 hrs. each. Total 102 hrs.

The turbine manufacturer wanted as much head as possible,so the turbine house was sunk 4 ft. in the ground. This also helps to keep the shack warm in winter and eliminated having to put an elbow on the pipe to get it into the shack. This basement type structure was much more complicated to build and the cost was also much higher. We did gain 3 ft. of head and the building is warm at 15 degrees below zero F. The G.I.D. had to do some backhoeing as we found the ground was seeping and had to be dug out 8 ft. Then we put in a drain and hauled in gravel to the 4 ft. mark. Jerry Nypen designed the tailrace to adequately handle our water flow so the wheel did not become flooded.

D. Shack: July 3, 1981
We got Sherman Idland, a carpenter from Fairfield, to do the work. It took him and two others 9 hrs. I spent a day in town gathering supplies (6 hrs.) Rick, helped the carpenters and did the insulating and finished the inside. This took him 4 1/2 days. Accordingto the turbine manufacturer,the shack had to be 2x6 costruction and insulated. See exhibit C.

E. Turbine and Electrical System: May 2-6 1981

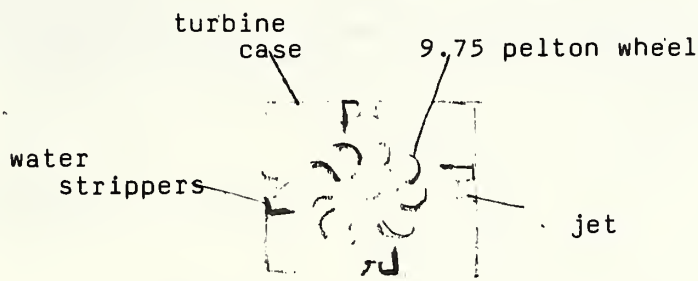
We went to seattle to get the system to save $800. The system was installed on July 3, 1981 by 2 tractors and 4 men. The turbine had to be bolted to the floor before the shack was built. The R.E.A. put in a pole and 3 transformers which took two days. The pipeline was connected to the turbine with a 12" - 15" collar (PVC).

Energy Equipment had told the R.E.A. what kind of hookup they needed and then changed their minds and the work had to be all redone.

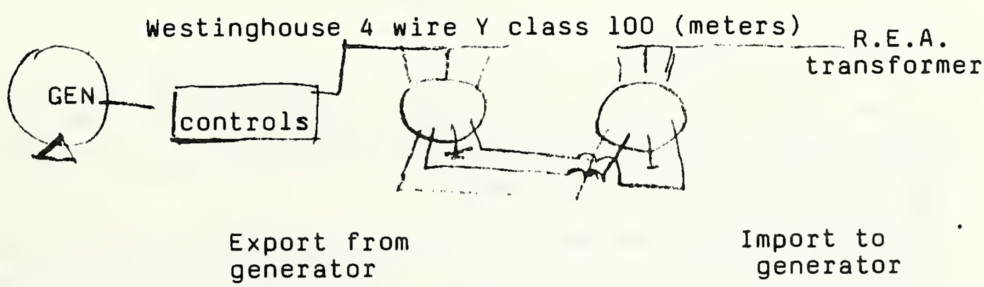
3. SYSTEM TESTING and MODIFICATION:

S.H.S.E. and Energy Equipment were to have tested the system at Cemco to make sure the electrical was working properly. We know now that this was never done because of all the flaws that we found later. The system was supposed to be tested and also an engineer from Cemco was to be there to do the hookup into the utility. The owner of Energy Equipment came to do the hookup and this is where our problems started. The R.E.A. came out to watch the turbine start and ended up trying to figure out why it wouldn't. The R.E.A. then wired the solenoid, which shuts the whole system down in case of an emergency, to 440 instead of 120 and it blew up. We eventually had to go to a larger solenoid after 3 of them burnt up. Then the meter head was the wrong size and it almost blew up. The R.E.A. couldn't get thesystem to shut off and really scared them. Because of this they are requiring a outside disconnect on every induction type generation. Fuses were also in the wrong spots and we blew up several of those. They do not carry these fuses in stock so they had to be ordered from Cemco. After each one of these things happened we had to order parts, wait till they arrived and then get the R.E.A. to come back out. We were not allowed to go on line until they were satisfied with everything. This cost over $1000, by the time we paid mileage and $20/hr for 1 engineer and sometimes two or three would come out. We are still working with the system since it went on line April 1982, to bring the K.W.s up. We have gotten it from 2k.w. to 10k.w. which was last week. I am sending you the new blueprints of the electric system after it was redesigned in April 1982. After trying to convince Energy Equipment to do something we went around them to Cemco. They came out on their own and fixed it at their expense. They had not been informed that we were having a problem. Energy Equipment and S.H.S.E. both said that the problem was with the R.E.A. and they are still using this as an excuse not to help us bring this up to capacity. There was a knock in the pipe and we found a caliper in one of the jets. There were three 1½" jets and one 17/8" jet which caused an imbalance in the water pressure and a drop in K.W. when that jet was opened. We now also fill the pipeline very slowly to eliminate air in the line which also drops the power. We installed a pressure guage on the turbine pipeline which also tells us if there is air in the pipe as well as the pressure we have hitting the turbine. From this you can calculate water horsepower. When we started experimenting with different size jets,it also told us when we were dropping the pressure on the wheel because the jets were to large. At this time our K.W.s. were as follows; 1jet- 2.5kw, 2 jets- 5 kw, 3 jets- 5.25 kw and 4 jets- 2.5 kw. Ten months were wasted just waiting for the electrical to be fixed before we could even start on the turbine end of the system. I will go through more of the problems next. The tach on the generator didn't work but it was calibrated in degrees of 50. On a water turbine the rpm of the generator and turbine pulleys are proportionate to the

k.w.s put out. We needed a tach that would read to 1 degree. The D.N.R.C. supplied this for us to use. The maximum rpm on the generator is 1840. At this speed we should obtain 21 k.w. The highest we have been able to get the rpm was 1810. At that rpm we are getting 9.75 k.w. The pulley size they say we need is 5.9" but no one makes one. We are waiting to see if we can get one made. Right now there is a 6.0" pulley on the generator. We had a 6.9" and got 6.5 k.w. Then we got a 6.5" pulley and got 7 k.w. The turbine pulley is a 19". We also tried different size jets, 1½",15/8, and 1 7/8. The 1 7/8" jets gave us the most k.w. In fact we ran the turbine with two jets off and obtained 1 more k.w. But, we caused so much suction that we pulled rocks out of the banks of the stream and plugged the jets. We have since built a trash rack to handle this problem and our moss problem. We also installed water strippers on the sides of the jets to keep the water from one jet from nullifying the water from the next jet. They look like this.

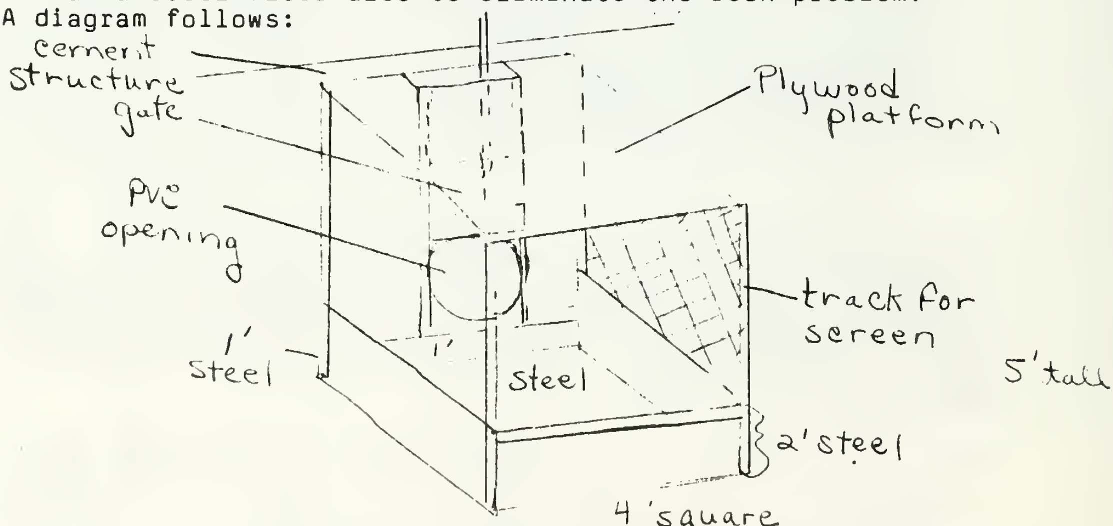


These also brought up the output about 2 k.w.
The R.E.A. checked our k.w. meter for accuracy with a clamp-on ammeter and by calculating it from their meter. Metering can also cause problems. On the bottom of this page is a diagram of our metering setup. See exhibit D for other metering diagrams and the problems they encounter with them.



Both meters have detents on them.

We tightened the belts on the pulleys and gained some and then we adjusted the deflectors that shut the system down and brought it up to 9.9-10 k.w. last week.
The R.E.A. also checked the power factor and it was 9.1-9.6 on their line and 4.7 on our generator. We have been told that the farther you are from obtaining the maximum k.w. on the generator, the worse your power factor is.
We discovered today that as we opened each jet for more power that the power factor got worse. The R.E.A. is going to bring out capacitors and see if we can't get the power factor up as this will increase our output also. If the cost of the capacitors are to much,it may not be feasible to put them on thesystem.
As soon as the spring run off started we began to get alot of rocks in the jets, even though we had a screen over the inlet. In August, the screen had to be cleaned once a day because of pond weed. We would pull the screen to clean it and the rocks would be pulled in even worse. We began looking for an efficient and economical trashrack. We ended up designing our own. The cost of a trashrack was from $8oo-$7,000 and they didn't sound like they were very efficient on pond weed. It was made of steel with expanded steel screens. It has a steel floor also to eliminate the rock problem.
A diagram follows:



It has a dual track so that another screen can be slid in place if the front one must be pulled to clean it. We decided to manually clean ours as we didn't want to use up more k.w. So far not one rock has plugged a jet as the holes in the screen are smaller than the jet holes.
I forgot to add that most of the problems concerning our electical were due to having a 4 wire lead put into the shack and a 3 wire setup in the panel. The relays were also wired phase to phase instead of phase to neutral. Cemco had also left out some potential transformers.
The final system design is as follows; A steel trashrack,

a waterman turnout leading into 1520 ft. of 15" PVC. Then we go to a 15x12" PVC reducer and past a pressure guage to the first jet (all 1 7/8"). We are now in 10" steel pipe and are making a 90 degree corner. Past each corner of the [illegible] delivery pipe it decreases 2". The wheel itself is a stainless steel 9.75" pelton in a horizontal position. A 19" pulley is on the turbine and is connected to the generator with 4 cogged v-belts. There is a 6" pulley on the generator. The generator is connected in conduit to an electrical panel bolted to the wall of the shack. Directly behind this panel on the outside is an outside disconnect. A complete diagram is shown as exhibit E.

4. SYSTEM PERFORMANCE:

We needed to find the exact r.p.m. of the two pulleys. There is a six inch pulley on the generator and a 19 inch on the Turbine. This would let us know if we didn't have enough power to turn the generator fast enough or if the pulley ratio was off. We needed 1840 r.p.m. on the generator to produce 22 k.w. and we have 1808 r.p.m. We would only get 22 k.w.s at 100% efficiency which is impossible. The turbine and the generator have a 85% and a 93% respectively

These are the digital tachometer readings from the spring of 1982:

	R.P.M. (generator)	R.P.M. (turbine)	K.W.
#1 jet	1798	566	2
#2 jet	1805	568	4.5
#3 jet	1808	569	6.75
#4 jet	1810	572	8.75

The tachometer was loaned to us by the D.N.R.C. Jet # 1 is always the first jet in the turbine pipeline. This showed us that some of our problem with bringing our k.w. up was in this area. This was the best r.p.m. that we obtained off the three pulleys that we tried. We talked with Bearings Inc. who supplied the pulleys and they said to bring it up any higher we would need a 5.9 inch on the generator. This would give us 1841 r.p.m. The only problem being, they don't make a 5.9 inch and neither does any one else. We are waiting to hear from them to see if we can have one made in a machine shop or the 6.0 inch machined down. We were going to go bigger on the turbine, the next size being 25 inch, but we found out that at this size the large one could explode.

The following readings are from a Collins Flow Gauge. They were taken by Jerry Torgeson. This checks the p.s.i. and c.f.s. of the water. From this you can calculate water horsepower and your accurate head.

21.5 p.s.i. x 2.31(lbs./ft.) =49.7 ft. static head
20,75 p.s.i.x 2.31 " =47.9 ft. running head
1 ft.=.433 p.s.i. 50 ft head x .433= 21.65 p.s.i.

the c.f.s. was 5.45-5.5. This was during a low flow season.
5.45 c.f.s. x 363.9= 1983 gallons/ minute

net $\frac{\text{head x gpm}}{3960}$ =hp $\frac{47.9 \times 1983}{3960}$ =24 water hp

$\frac{\text{head x gpm}}{5.3}$ = watts $\frac{50\text{x } 1983}{5.3}$ =18,707 watts (18.7 k.w.)

This is how much k.w. we should be generating and we are generating 10 k.w. The following calculations figure our systems efficiency:

$.746/\text{hp} \qquad \frac{10 \text{ k.w.}}{.746} = 13.3$ elec. hp going into utility lines

10 k.w. is the output we have on the electric panel.

.746 x 24 water hp = 17.904 k.w.
17.9 k.w. potential k.w. from water hp
-10.0 k.w. actual k.w. on electric panel
 7.9 k.w. loss between first jet and electric panel

$\frac{\text{electric hp}}{\text{water hp}}$ = total system efficiency $\frac{13.4}{24} = 55.8\%$

This is the total system effeciency from pipeline to panel.

By using the following formula we computed our hp (net).

$$\text{Hp} = \frac{62.4 \times \text{cfm} \times \text{head}}{33{,}000} \times \text{efficiency}$$

$$16.7 = \frac{62.4 \times 330 \times 48}{33{,}000} \times 55.8 \qquad .746 \times 16.7 = 12.45 \text{ k.w.}$$

Taking everything into consideration, we should be showing 12.45 k.w. on the electric panel at 55.8 % total system efficiency.

The power factor also affects the k.w. output. The p.f. at the substation 10 mile away is 91-96%. The power factor coming off of our system is 47%. Which is very poor and it also eats up the k.w.s that we make. We used a Acme Power Factor Meter (model R). It was checked by Jerry Torgeson. All the material we had read stated that, the farther away the system is from reaching it's maximum capacity, the worse the power factor would become. As we opened each jet and the k.w. went up the power factor got increasingly worse. We are still trying to find more information on power factor so we can correct our system with capacitors if the cost isn't to great. If the R.E.A. is ever required to correct it's power factor, we will be required to do so also. The following formula shows what a poor power factor does to your k.w.

$$\text{K.W.} = \frac{\text{volts} \times \text{amps} \times 1.732 \times \text{P.F.}}{1000}$$

$$8.63 = \frac{480 \times 22 \times 1.732 \times .47}{1000}$$

At the time this was done we were getting 9.5 k.w. The difference between the two k.w.s is the loss due to power factor.

9.5 minus 8.63= .87 k.w.

I am including a nomogragh chart, as it is very accurate on the k.w. you should be able to expect from various flows and heads.
(See exhibit F)

We have tested the system many times to try to increase our k.w. I will list them in order by date and explain what was done to bring the k.w.s up. We had to brace the solenoid up so the deflectors would move out of the way, as the electric system was messed up for nine months.

Sept 18, 1981

#2 jet	5 k.w.	(6.9" pulley 1½" jets)
#3 jet	5.25 k.w.	
#4 jet	2.50 k.w.	

We put in water strippers (See system testing for diagram).

Sept. 24, 1981

(6.5" pulley 1 7/8" jets)

#4 jet	2½ k.w.	22 psi
#4-3	4 k.w.	22 psi
#4-3-2	5½ k.w.	22 psi
#4-3-2-1-	6½ k.w.	21 psi

We put a smaller pulley on the generator and 1 7/8" jets.

Sept. 24, 1981

(6.5" pulley 1 ½" jets)

#4	3/4 k.w.	22 psi
#4-3	2 3/4 k.w.	22 psi
#4-3-2	4½ k.w.	22 psi
#4-3-2-1	6½ k.w.	22 psi
#3-2-1	5 k.w.	22 psi
#1-2-4	5 k.w.	22 psi
#1-3-4	4 3/4 k.w.	22 psi

This jet did not produce the k.w. that the 1 7/8 did. We also noticed that we get differing k.w.s by opening different sets of jets. The reason for this is explained [illegible]

Mar 1982

#1 jet	
#2 jet	2.5 k.w.
#3 jet	5 k.w.
#4 jet	7 k.w.

This was the lowest flow of the year. This is before spring run off. All subsequent readings are with the 6.0" pulley and 1 7/8" jet.

Mar. 1982

#1 jet	2.5 k.w.
#2 jet	5 k.w.
#3 jet	7 k.w.
#4 jet	9 k.w.

We had more water on these readings.

In March and April 1982, Cemco, sent two engineers out to check out the electric panel. They found that the R.E.A. had put a 3-wire lead into the panel and they needed a 4-wire.

Cemco, had also left out potential transformers and fuses. They also had to change the relays as they were seeing to much current. The relays were wired phase to phase instead of phase to neutral. All the electrical has been working correctly since April.

July 23,1982

(2 jets out)

#1 jet	2½k.w.
#2 jet	5½k.w.
#3 jet	7 k.w.
#4 jet	9½k.w.

With the jets out we sucked rocks down the pipe and plugged the jets. But, we got ½ k.w. more with 2 jets out and the deflectors on. This is when we began to think we needed a different type of turbine. This one needed more pressure to get the power up.

July 23, 1982

(all jets in)

#1 jet	1½k.w.
#2 jet	4½k.w.
#3 jet	6½k.w.
#4 jet	9 k.w.

Aug 1982

#1 jet	2½k.w.	1.4 cfs	21.5 psi
#2 jet	5 k.w.	2.9 cfs	21.5 psi
#3 jet	7½k.w.	4.1 cfs	21.25 psi
#4 jet	9½k.w.	5.3 cfs	20.75 psi

We were using the Collins Flow Guage. WE also tightened the belts. We found that we get ½ more k.w when we open jet #4 and #1 than #1 and #2. This is because the jets are not balanced. Jerry Nypen, our engineer, ran the following calculations to see if the jets were sending out the same amount of water. The wheel will be being pushed unequally if they are not the same. He used the velocity of the water and the size of the pipes that go to each jet. See exhibit G for a Diagram of the turbine.

15" $V_1 = \frac{4}{1.23} = 3.2$ ft/sec PVC

12" $V_1 = \frac{4}{.79} = 5.1$ ft/sec steel

10" $V_3 = \frac{3}{.55} = 5.5$ ft/sec steel

8" $V_4 = \frac{2}{.35} = 5.7$ ft/sec steel

6" $V_5 = \frac{1}{.20} = 5.1$ ft/sec steel

Jet #1 is the 12" pipe and #4 is the 6" pipe. AS you can see these two jets are balanced as far as the amount of water they emit.

We were very concerned with what cold temperatures would do to our system. It has been below zero for several nights now. As of yet, it has been relatively warm in the turbine shack. We attribute this to the insulation and berming. Especially, when the door is not on the shack yet. The water in the ditch has ice on it but, the water in the ditch is moving fast enough underneath to keep it from freezing. A piece of plywood is on the top of the trashrack at the headworks, acts not only as a platform to check the screens but, it also keeps some of the waters heat in.

5. SYSTEM COST:

	Grant Request	Expenses Other	Total
I. Salaries			
A. Jerry Nypen (our engineer) (all Jerry's labor was furnished)	$0	$0	$0
B. Hired labor (pipeline)	$0	$105	$105
C. Construct shack	$0	$306	$306
II. Operating Expenses			
A. Contracted Services			
1. Greenfield Irrigation District (backhoe expense)	$877.48	$0	$877.48
2. Sun River Electric (labor and mileage)	$607.30	$0	$607.30
3. Augustine Concrete (72 hrs. @ $21 + $40 travel)	$796.00	$0	$796.00
B. Machinery hire			
1. tractor,truck,backhoe,cat (30x$10,4x$10,20x$30,20x$20)	$0	$1340.	$1340.00
2. Gas (458 gal.@ $1.20)	$0	$ 550	$ 550.00
C. Supplies and materials			
1. turbine house			
a. cement	$673.50	$0	$673.50
b. lumber	$156.15	$0	$156.15
c. metal roofing	$ 81.12	$0	$ 81.12
d. siding	$104.39	$0	$104.39
e. insulation (4x$20.92)	$ 83.68	$0	$ 83.68
f. plywood (35x$5.29)	$0	$185.15	$185.15
g. steel mesh	$270.65	$0	$270.65
h. forms	$197.00	$0	$197.00
i. corr. metal pipe (tailrace)	$101.68	$0	$101.68
k. nails	$ 33.90	$0	$ 33.90
2. pipeline			
a. 1440 ft. 15" PVC (@ $5.32/ ft + turnout)	$7817.16	$0	$7817.16
b. 100 ft. 15" PVC (@ $5.15/ ft.)	$ 515.00	$0	$ 515.00
c. screen	$0	$ 3.50	$ 3.50
III. Equipment			
A. 9.75 pelton turbine (18-21 k.w.)	$7600.00	$0	$7600.00
B. Louis Allis generator (1840 rpm induction)	$1219.80	$0	$1219.80
C. Electric switch gear	$4000.00	$0	$4000.00

I forgot some under section II. C. and then I will go to IV.

3. Electric connection			
a. Transmission lines and poles	$0	$0	$0
b. Safety power disconnect	$223.34	$0	$223.34
c. Interconnecting to grid	$405.06	$0	$405.06
d. fuses (10@$5.25 +80¢)	$0	$ 53.30	$ 53.30
4. Misccellaneous parts and supplies			
a. trash rack	$202.56	$0	$202.56
b. solenoid	$ 43.36	$0	$ 43.36
D. Communications			
1. Telephone (1980-1982)	$0	$615.00	$615.00
2. Mail	$0	$ 85.00	$ 85.00
E. Travel			
1. Trip to Seattle (meals $144 +motel $150)	$0	$194.00	$194.00
2. Trip to Noxon and Sandpoint	$0	$ 80.00	$ 80.00
3. To Klick's turbine	$0	$ 30.00	$ 30.00
F. Rent			
1. Jack-hammer (2 days@ $25/day)	$0	$ 50.00	$ 50.00
IV. Administration			
A. Insurance ($1,000,000 liability policy required by R.E.A.)	$0	$458.00	$458.00

Summary of Budget

	Grant	Other	Total
I. Salaries	$0	$ 411.00	$ 411.00
II. Operating Expenses	$13,189.33	$ 3185.95	$16,375.96
III. Equipment	$12,819.80	$ 0	$12,819.80
IV. Administration	$0	$ 458.00	$ 458.00
TOTAL (Grant)	$26,009.13		
TOTAL (Other)		$ 3949.95	
TOTAL (Project Cost)			$29,959.76

The amount granted was $25,000.

6. ECONOMIC EVALUATION:

The chart on the following page is an estimate of how many k.w. hrs. we will make, use and sell. It also tells what the R.E.A will charge us per month for generating. We used previous years flow records to get the number of jets that we could run for different months. This month will be our first month to run without problems. With the electrical and trash problems solved we have now been running continuously since Nov. 18, 1982. From Nov. 18- Nov. 23 we made 1000 k.w. hrs. This was running 3 jets for 12 hours and 4 jets for 12 hours. Since then we have been running all four jets.

The manager of the R.E.A. decided that we would only be able to use our home meter against the turbines output rather than the whole farm. For example, we will make approximately 5130 k.w. hours this month. We will use 3077 k.w. hrs in our house. They will deduct the 3077 from the 5130 = 2053 k.w. hrs extra. They charge 2.6¢/k.w. hr. We are actually getting2.6¢ for each k.w. we use in our home but the excess 2053 k.w. hrs., they will buy for .00598¢/k.w. hr. The rest of the farm we must buy power for at the 2.6¢ rate. We are also being charged a $20.00/ month kva charge for our transformers, plus a $5.00 a month house charge. Everyone must pay the home charge. We have to make 3344 k.w. hrs./month to break even. The generator will make approximately 73,530 k.w. hrs/ year. If we got 2.6¢/k.w.hr. we would make $1912.00 minus $240 kva charge. this would be $1672 net. But, we only get .00598¢ for 45,652 kw hrs. which is $273.01. The R.E.A. pays us their "voided costs". Yearly we would make $785 that the house uses and $273.01 that we sell. This would be $1058.01 minus a $240 kva charge which would be $818.01. They will let us put the shop and stock waterer on only if we run a new line from our house meter about 1000 ft to the other buildings. We are at present looking into this to see if it is feasible. We could also put capacitors on to help the power factor. But, we need to bring the k.w.s up first. We could also buy the transformers, but they would cost us $1800. At the $240 kva charge/ year it would take us 9 years to pay them off. As you can see we can't afford to spend alot to bring the k.w.s up if all we will get is the .00598¢/ k.w.hr. If we doubled our output we would only make $645/ year extra. I can see no possible way to reduce the cost of our system. The only job we could have done ourselves was the turbine house construction. We were in the middle of haying at the time because of time delays on getting our equipment. We have done most of the troubleshooting on the turbine which is very expensive, if you can find anyone to work on them.

I really needed a few months for a more accurate economic analysis. We got it up another ½k.w. last week alone. We would have an additional $753.99/ year if we put in the new line. We will be getting bids back on this sometime this month. I wil give you a payback for the net as it is now and what it would be with the new line.

Payback: $29,959.07 is the total project cost

$\frac{\$29959.07}{\$818.01 \text{ net}}$ = 36.6 years payback. at present utility rates

$\frac{\$29959.07}{\$1672.00}$ = 17.9 years payback, if we run new line, at pre- utility rates (73530 k.w.hrs./yr x .026¢ /k.w.hr. - $240 kva=$1672

There is to be an increase in our rates in January 1983. They have not told us how much it will be yet.

The following chart is using a 360 day year, 30 day month. For each month we have figured our average flow andby this have estimated how many jets we can use. We figured 7½k.w. for 3 jets and 9½ k.w. on four jets. We are now getting ten k.w. on four jets.

jets	months	home usage	cost	generation (kwh)	sold(kwh)	income	cost KVA charge
3	1	3077	$80+5	5150	2053	$12.28	$20
3	2	2885	$75+5	5130	2250	$13.46	$20
3	3	2692	$70+5	5130	2438	$14.58	$20
3	4	2307	$60+5	5130	2823	$16.88	$20
4	5	1923	$50+5	6840	4917	$29.40	$20
4	6	1731	$45+5	6840	5109	$30.55	$20
4	7	1538	$40+5	6840	5302	$31.71	$20
4	8	1731	$45+5	6840	5109	$30.55	$20
4	9	1923	$50+5	6840	4917	$29.41	$20
4	10	2307	$60+5	6840	4533	$27.11	$20
4	11	2692	$70+5	6840	4148	$24.81	$20
3	12	3079	$80+5	5130	2053	$12.28	$20
		27,883	$725+$60	73,530	45,652	$273.01	$240

III. Conclusions and Recommendations:

Our project will be very helpful in providing shortcuts in obtaining, installing, and troubleshooting hydro-turbines systems. The ideas we have may help someone devise a better system for less money. If we were to start from scratch now, it would be much easier to get the data we needed to decide on a system. We would do several things differently with what we know now. They are as follows:

#1. We would install a crossflow with our head and flow. We have one picked out. It is made by Appropriate Technology in Idaho. We received their bid to late. We have talked with several companies recently and it looks like turbines are getting more efficient as understanding and demand increases. Appropriate Tech. also builds our turbine and gets the supplies from S.H.S.E. But, they won't put it on anything under a 200 ft. head. And they never make a 4 jet. They said that all it did was utilize more water with not much extra output. We believe our head is to low to obtain the amount of pressure needed for a pelton. We had been told this by a sales rep. from G.E. but were told the opposite from S.H.S.E.

#2 We would buy a complete package from one manufacturer. Everytime we encountered a problem, it was the other dealers problem. We lost 9 months because of this problem and we are still losing k.w. because S.H.S.E. says it must be our utility that's causing our low k.w.

#3 We learned in Nov. 82 that Louis Allis generators are one of the worst for poor power factor. We wouldn't go with this again. This information came from Ron Adams (turbine troubleshooter).

#4. We would also check on turbines previously sold by the manufacturer. It's one thing to say you'll get a certain k.w., and quite another to get it. We were told our system would be 83-85% efficient. This figure may only be the turbine and not all the inefficiencies of the pipe. generator, belts, and the electric loss. The 55.8% efficiency of our total system is far from the 83-85% we were promised. Dick Klick, of Augusta also has one of S.H.S.E.'s turbines. He was very satisfied with the output. But, being his system was D.C., and a 2 jet also, it was not close enough to our system to make any comparisons as to efficiencies. With ours being one of the first, if not the first, induction in the state, no other systems could we compare ours to.

It would be much earier hiring a consulting firm to do all the research. But, we didn't feel that the cost was justified. We also felt that this could be our contribution to obtaining a turbine since we were granted funds for our project. This project took two years of research to just

find a turbine that we felt was the best. Now, it would take very little time to find the components you need. They have even developed a single-phase induction system. This would be much simpler and cheaper to install. We would go single-phase now and eliminate our $20/month kva charge.

With the R.E.A.'s low buy back rate, it tends to discourage people that are interested in installing an alternative energy project. If we brought our system up to capacity and were paid 2.6¢ we would pay off the system in 7.1 years. Other utilities, including some R.E.A.s, are paying much higher rates and encouraging people to develope the resources around them. Our R.E.A. could have been much tougher than they were. We still have many years to work together and by showing them how compatible we are with their system they may get a different prospective on alternate energies.

The most frustrating part of this whole process was not having anyone to go to for help to troubleshoot the system. We have just recently found someone who we hope can help. His name is Ron Adams.

We should have had some device to tell us when the system has shut down. This should have been laid in the trench with the pipe. We could put a light on the top of an electric pole. We checked into an intercom setup, but it wouldn't transmit that far, it was wireless. Right now, if the power fluctuates more than 10 seconds and my microwave clock goes off, we know that we are down.

Anytime, you are opening up a new technology, there will be disappointments and frustration and we've had our share.

We attribute the success we have had to the determination to see this project through. I believe this one factor alone can make or break a project such as this. I have enjoyed this endeavor so much because I believe in what Alternative Energy stands for. This quote by Ivan Illich, says it all. "Act so that the effect of your action is compatible with the permanence of human life."

IV. MONITORING:

All the performance data will be compiled and sent to the D.N.R.C. The meters are read once a month by the R.E.A. I am required by them to keep a log of what the turbine is doing. We will be sending you these things plus all new data twice a year. If this alright with the department. I will send them in Nov. and May. If we make any significant breakthroughs we will let you know right away, as it may be beneficial to someone.

V. PUBLIC AVAILABILITY:

It is most convenient for us to have people come to review our project from November-April, Monday-Friday, 9:00-4:30. Other arrangements can be made if need be. You can contact us by phone or mail.
As of June 1981, we had 100 people contact us to see the turbine. Therewere approximately 70 more in 1982. Because turbines are nonexistant in our area they are kind of a mystery. It was not as complex an apparatus as most people had thought it would be. The electrical part was a little more complicated to explain to the average person. The question most asked was, "where did you ever get this idea". Almost everyone thought we were getting in on the ground floor of a whole new field and they were really intriqued. People traveled from Seattle and all over the state. There were also many here from Wyoming (from irrigation district offices) to see the turbine. Richard King, a student from Bozeman, came last Dec. and used our turbine in a movie he was making. We received a letter from him that it was completed and that it would be made available for our viewing. The name of it is " Renewable Renaiisance". People that are working on their own hydro projects also contacted us. Lee Tavenner-Flint Hydro, John Ohrmann, Dave Shipman, Tom and Diane Anton- Bozeman, Tim Antonson, Roger Kirk, Wayne Kelly Charles Greene-ASCS office- Bozeman, John Manly, Allan Kachelmeier-Bellingham, Wa., were some of them. By educating our R.E.A they have become a source for people to get information from also.

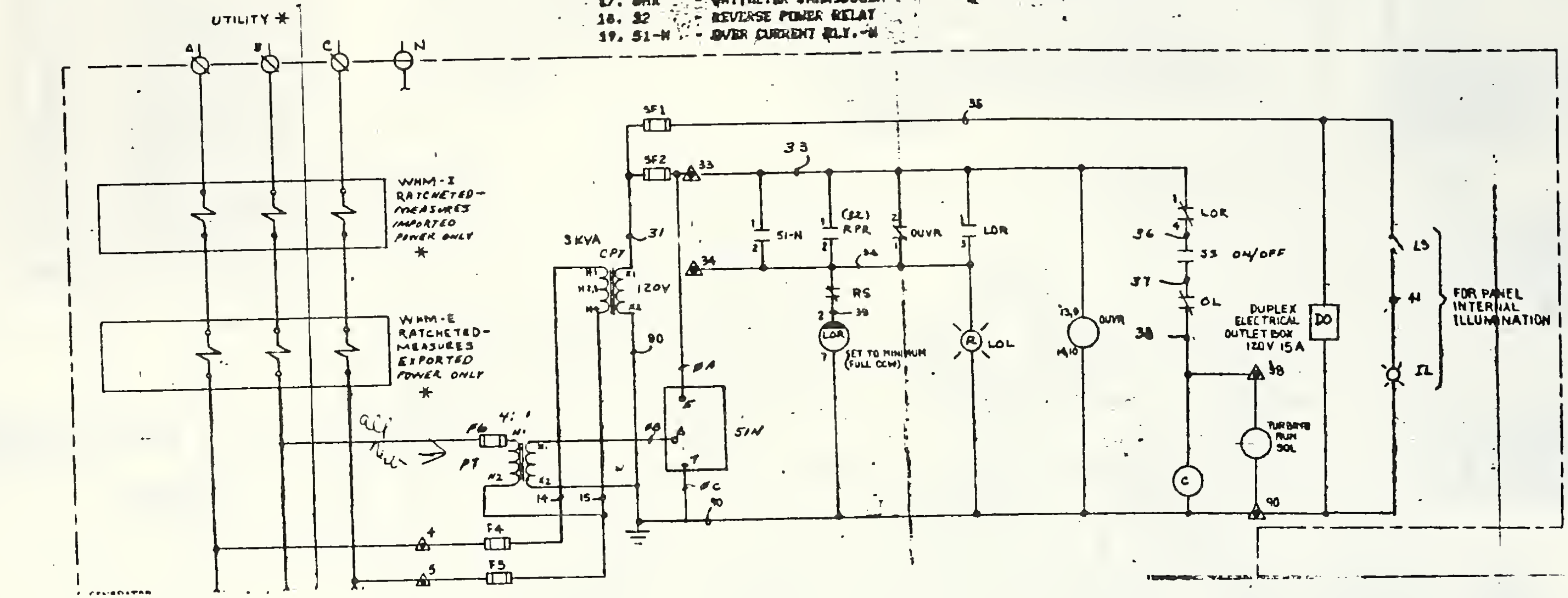
VI: Progarm Evaluation:

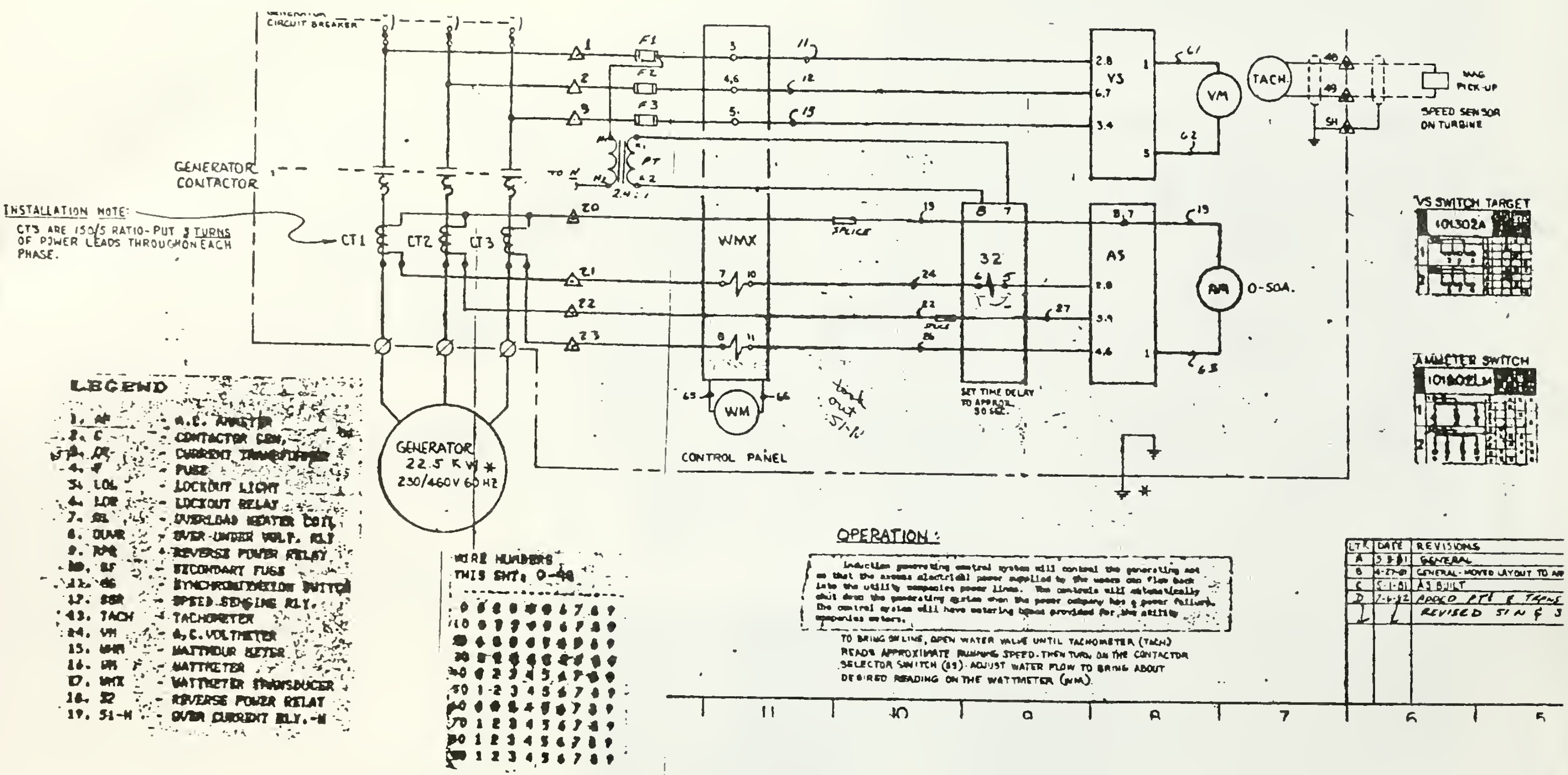
We feel that the Renewable Energy program is the most beneficial program that the State has to offer. They provide an unbiased source for persons needing information on alternative energy. I have picked up many publications on many different subjects. These were all beneficial and easy to understand. These publications as well as your t.v. and newspaper articles, are making people more aware of the resources we have and how to use them. The D.N.R.C. monitored us very closely. But, at no time did we feel that they were interfereing. They were always trying to help if they could. When I started looking for information on hydro, the D.N.R.C. was also gathering data on turbines. This made it difficult for me as it was such a new field to work in. There has to be trial and error experiences to draw from when developing new technology. The D.N.R.C., provides the opportunity,as well as the know how,to develope these new areas of energy. By offering financial help, you are offering an incentive that stimulates an interest in renewable energy. Our project would only be a dream without this help. We have beentrying for weeks to think of some changes that would help the energy program. So, far we can't think of a thing that we would change. We would like to thank you for your support and help with our project.

LEGEND

1. AM - A.C. AMMETER
2. C - CONTACTOR GEN.
3. CT - CURRENT TRANSFORMER
4. F - FUSE
5. LOL - LOCKOUT LIGHT
6. LOR - LOCKOUT RELAY
7. OL - OVERLOAD HEATER COIL
8. OUVR - OVER-UNDER VOLT. RLY
9. RPR - REVERSE POWER RELAY
10. SF - SECONDARY FUSE
11. SS - SYNCHRONIZATION SWITCH
12. SSR - SPEED SENSING RLY.
13. TACH - TACHOMETER
14. VM - A.C. VOLTMETER
15. WHM - WATTHOUR METER
16. WM - WATTMETER
17. WMX - WATTMETER TRANSDUCER
18. 32 - REVERSE POWER RELAY
19. 51-N - OVER CURRENT RLY.-N

WIRE NUMBERS
THIS SHT. 0-99




GENERATOR CIRCUIT BREAKER
GENERATOR CONTACTOR
INSTALLATION NOTE:
CTS ARE 150/5 RATIO- PUT 3 TURNS OF POWER LEADS THROUGH ON EACH PHASE.
CT1
CT2
CT3
GENERATOR 22.5 KW * 230/460V 60 HZ
F1
F2
F3
PT
2.4:1
TO N
WMX
WM
CONTROL PANEL
SPLICE
32
SET TIME DELAY TO APPROX. 30 SEC.
VS
AS
VM
AM
0-50A.
TACH.
MAG PICK-UP
SPEED SENSOR ON TURBINE
VS SWITCH TARGET
101302A
AMMETER SWITCH
LEGEND
1. AM - A.C. AMMETER
2. C - CONTACTOR COIL
3. CT - CURRENT TRANSFORMER
4. F - FUSE
5. LOL - LOCKOUT LIGHT
6. LOR - LOCKOUT RELAY
7. OL - OVERLOAD HEATER COIL
8. OUVR - OVER-UNDER VOLT. RLY
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12. SSR - SPEED SENSING RLY.
13. TACH - TACHOMETER
14. VM - A.C. VOLTMETER
15. WHM - WATTHOUR METER
16. WM - WATTMETER
17. WMX - WATTMETER TRANSDUCER
18. 32 - REVERSE POWER RELAY
19. 51-H - OVER CURRENT RLY.-H
WIRE NUMBERS THIS SHT: 0-48
OPERATION:
Induction generating control system will control the generating set so that the excess electrical power supplied by the users can flow back into the utility companies power lines. The controls will automatically shut down the generating system when the power company has a power failure. The control system will have metering provided for the utility companies meters.
TO BRING ON LINE, OPEN WATER VALVE UNTIL TACHOMETER (TACH) READS APPROXIMATE RUNNING SPEED. THEN TURN ON THE CONTACTOR SELECTOR SWITCH (SS). ADJUST WATER FLOW TO BRING ABOUT DESIRED READING ON THE WATTMETER (WM).
LTR DATE REVISIONS
A 3-3-81 GENERAL
B 4-27-81 GENERAL-MOVED LAYOUT TO AP
C 5-1-81 AS BUILT
D 7-6-82 ADDED PT & TRANS
REVISED 51 N & 3
11
10
9
8
7
6
5

EXHIBIT A

HYDROPOWER
EQUIPMENT MANUFACTURERS & HARDWARE SUPPLIERS

DOE
Boise, Idaho
Idaho National Engineering Lab
Idaho Falls, Idaho 83415

DOE Region VIII
Clarence Council
U.S. Dept of Energy
P.O. Box 26247 Belmor Branch
1075 South Yukon Street
Lakewood, Colorado 80226

Hydropower Programs
Idaho Falls, Idaho 83415
(208) 526-9960

Mc Gillvary, Jerry
Chinook, Mt
(Has wind generator hooked to MPC)

Tibbetts, Val
Hamilton, MT
(406) 363 5242
(Trash rack, self propelled)

Bradley, Phil
Lewistown, MT

The National Center for Appropriate Technology
P.O. Box 3838
3040 Continental Drive
Butte, MT 59701
(406) 494-4572

Ossberger
D-8832 Weissenburg/Bay
P.O. Box 425
Weissenburg, Germany
(0 91 41) 7 90

A. B. Bofors-Nohab
S-46101
Trollhattan
Sweden

Cemco (Transelectro)
14 S.
Seattle, Washington 98134
(electric systems turbines and troubleshooting)

Energy Equipment Co.
P.O. Box 10667
Bainbridge Is. 98110
(206-842-7338) (electrical supplies)

Short Stoppers Electric (Mert Hunking)
Rt. 4, Box 471B
Coos Bay, Oregon 97420
(electric systems and installation)
(503) 267-3559)

Ron Adams
Energy Control Systems of Lake Oswego
16841 S.W.Cortez Ct.
Lake Osego, Or. 97034
(503-636-8745)
(electric systems and troubleshooting)

Bearings Inc. (Bud Cole)
Everett, Washington
(206-259-5585)
(help with pulley ratios and speeds)

John Zabukovac
Transelectro
14 S,Idaho
Seattle, Washington 98134
(excellant electrical troubleshooter)

George Conrad
Bozeman
Mt.
(elec, eng. troubleshooter)

Jerry Torgeson
c/o R.E.A.
Fairfield, Mt. 59436
(406-467-2526)
(electrical systems and utility lines expert)

Jerry Nypen
c/o Greenfield Irrigation District
Fairfield, Mt. 59436
(406-467-2533)
(our Engineer)

Redwheel Water Works
Monroe, Oregon 97456
(503) 847-5771
finds equipment to suit your site

Childs and Assoc.
1317 Commercial St.
BellinghAM, WA. (98225)
(206) 671-0107

Kirk, Roger (mech. eng.)
201 s. 3rd
Bozeman, Mt. 59715
(406) 586-4474

Richard Wrench
295 Highland Dr.,Kalispell,Mt 59901

Hydro Energy Systems Inc.
2 World Trade Center
New York, N.Y. 10048

Canyon Industries
P.O. Box 2543
Bellingham, Wa 98225

Independent Power Developers
P.O. Box 1467
Noxon, Mt. 59853

The James Leffel and Com.
Springfiels, OH 45501
(513)323-6431

Keating and Assoc.
J.M. Keating
847 Pacific St.
Placerville, Ca 95667
(916)622-9013

Small Hydroelectric Systems and Equipment
5141 Wickersham
Acme, Wa. 98220
(206)595-2312

Appropriate Tech. Inc.
P.O. Box 1016
Idaho Falls, Idaho 83401
(208)529-1611
Attention Lloyd Donovan or George Smith

General Electric Hydo- Div. c/oDarrell Gordon
112 Andover Park East
P.O. Box 88850
Seattle Wa. 98188
(206)575-2839

Exhibit B

SUN RIVER ELECTRIC COOPERATIVE, INC.
FAIRFIELD, MONTANA
Montana -2- Cascade

ELECTRIC SERVICE AGREEMENT MEMBER OWNED GENERATION FACILITIES

AGREEMENT made this 25th day of March, 19 82, by and between SUN RIVER ELECTRIC COOPERATIVE, INCORPORATED of Fairfield, Montana (hereinafter called the "COOPERATIVE") and Richard and Earlene Ostberg (hereinafter called "MEMBER").

WITNESSETH:

WHEREAS, the MEMBER has indicated a desire to install electric generating facilities described on the attached Schedule A on his property located at ________________________; and

WHEREAS, the Member Owned Generating Facilities (hereinafter called Qualifying Facilities or QF) will utilize renewable resources as fuel and/or produce two forms of energy simultaneously and otherwise meet the qualification standards established by the Federal Energy Regulatory Commission (FERC); and

WHEREAS, the MEMBER wishes to generate electric energy for his own uses and sell any excess energy to the COOPERATIVE; and

WHEREAS, the COOPERATIVE, consistent with its policy of encouraging innovation in the energy field, is willing to interconnect and operate in parallel with the MEMBER Owned Qualifying Facilities and to furnish parallel electric service to the MEMBER for the operation of his generating facilities;

NOW, THEREFORE, the COOPERATIVE and the MEMBER agree as follows:

1. The COOPERATIVE shall purchase all power and energy made available by the MEMBER which are not supplied by the QF in accordance with the rate schedules applicable to the MEMBER'S class of service.

2. The COOPERATIVE shall purchase all power and energy made available by the MEMBER in accordance with the applicable rate schedule in effect, which shall be based on actual or projected "avoided costs" of COOPERATIVE, and effective superseding rate schedules.

3. The installation and operation of the QF shall be in accordance with the terms and conditions of the applicable rate schedule and rules, regulations and policies of the COOPERATIVE which from time to time may be modified or adopted by the Board of Trustees of the COOPERATIVE.

4. Prior to the installation of the QF, the MEMBER shall submit his plans and specifications for the facilities to the COOPERATIVE for its review and assure compliance with the COOPERATIVE'S rules, regulations and bylaws. Such review shall not be construed as permission to operate the facilities without written authorization from the COOPERATIVE after inspection of the completed facilities as hereinafter provided.

5. Prior to interconnection of the QF, the MEMBER shall notify the COOPERATIVE and the COOPERATIVE shall inspect the facilities for compliance with the rules, regulations and bylaws. The COOPERATIVE shall inspect and test the operation of the QF to assure the safety of its employees, and the satisfactory operation of the QF in parallel with the COOPERATIVE'S system before authorizing the operation of the facilities. Such inspection by the COOPERATIVE shall not relieve the MEMBER from his responsibility to install, operate, and maintain the facility in a safe and satisfactory manner.

6. The MEMBER shall reimburse the COOPERATIVE for the COOPERATIVE'S cost of providing additional facilities or modifying existing facilities including metering required to interconnect with the QF. Payment shall be due within 30 days of receipt of a statement thereof from the COOPERATIVE.

7. The COOPERATIVE may at any time install or modify its equipment as it deems necessary to insure the safety of its employees and the satisfactory operation of its system, and/or the accuracy of its meter as a result of the operation of the QF. The MEMBER shall reimburse the COOPERATIVE for the cost of such installation or modification within 30 days of receipt of statement thereof from the COOPERATIVE.

8. Authorized COOPERATIVE employees shall have the right to enter upon the MEMBER'S property at any time for the purpose of inspecting QF and making additional tests to ensure the continued safe operation of the QF and the accuracy of the meter. Such inspections shall not relieve the MEMBER from his obligation to install, operate, and maintain the facility in a safe and satisfactory manner.

9. If, in the sole judgment of the COOPERATIVE, the MEMBER has failed to maintain the QF in satisfactory operating condition, the COOPERATIVE may notify the MEMBER to disconnect the facilities from the COOPERATIVE system. In the event the MEMBER fails to immediately comply with such notice, the COOPERATIVE may discontinue service to the MEMBER until the QF is disconnected or restored to satisfactory operating condition.

10. The MEMBER shall have the sole responsibility for the safety and electrical protection of his facilities, irrespective of the condition of the COOPERATIVE'S facilities.

11. The MEMBER shall protect, idemnify and hold harmless the COOPERATIVE and its officers, agents and employees from any and all claims, demands, suits, liability and expense (including attorneys fees) by reason of any injury to or death of any person or damage to any property caused by or resulting from the QF.

12. The MEMBER shall procure and maintain the following types of insurance in the amounts stated:

A) General liability insurance in the amount of $1,000,000 per occurence or greater.

B) Property loss insurance in the amount of $250,000 or greater.

Each year the MEMBER shall provide the COOPERATIVE with proof of insurance and notify the COOPERATIVE at least 10 days before the termination or modification of the insurance coverage.

13. This Agreement shall become effective immediately upon the execution hereof and shall continue in effect until terminated by either party upon thirty (30) days written notice given to the other party. Termination shall require permanent disconnection of the facilities.

IN WITNESS WHEREOF, the parties have caused this Agreement to be duly executed as of the day and year first above written.

COOPERATIVE

Rod Hanson ______________________
Manager

Subscribed and
sworn before me this __________ day of ____________________ 19 ____________

______________________ ______________________
My Commission Expires Notary Public

Seal

MEMBER

____

Subscribed and
sworn before me this __________ day of ____________________ 19 ____________

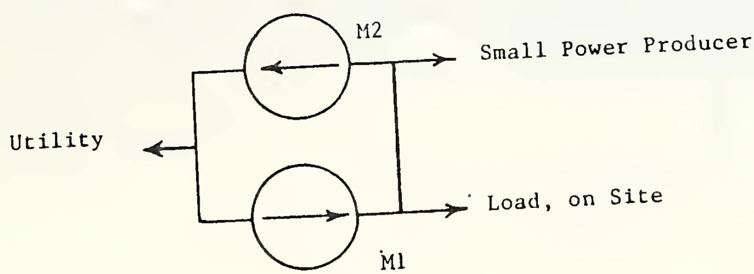
______________________ ______________________
My Commission Expires Notary Public

Seal

Exhibit C

Metering System B (Monodirectional--Two Meters.)

This metering configuration can be used to bill the consumer for his net energy consumption as explained in Metering System A or can be used for other tariff arrangements. Note that each monodirectional meter registers cumulative non-coincident kWh over the billing period. Whenever the facility generates energy, the coincident generation is consumed on-site, slowing meter M1. Excess (over coincident) and non-coincident energy is registered by meter M2. Thus, each meter registers the cumulative non-coincident energy which has been sold to and purchased from the utility.



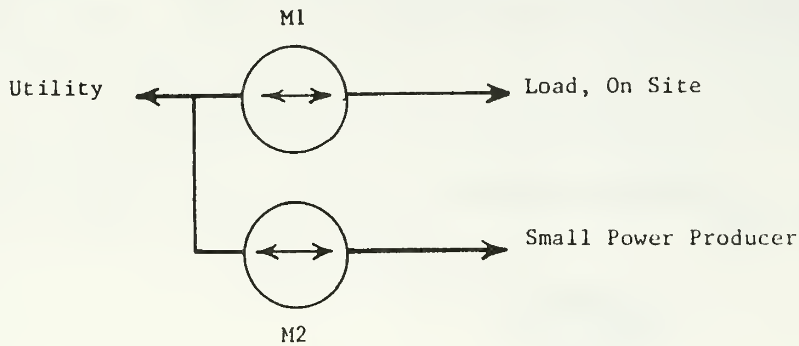
Characteristics

1. An additional meter and socket must be provided.
2. Each meter must be monodirectional.
3. Information is provided on the cumulative non-coincident (plus excess) energy flows.
4. An extra meter must be read and billing procedures adjusted accordingly.
5. Coincident owner produced generation offsets retail purchases from the utility, but only non-coincident and excess generation is registered (by meter M2).
6. No information is provided on the customer's total on-site consumption or the facilities' total generation.

SMALL HYDROELECTRIC SYSTEMS & EQUIPMENT
"PELTECH" Hydraulic Turbines
5141 WICKERSHAM STREET
ACME, WASHINGTON 98220
(206) 595-2312

Metering System C (Bidirectional--Two Meters)

...etering arrangement consists of two bidirectional meters, each separately metering ...all power producer and the on-site load. Meter M1 is the pre-existing meter and ... M2 is added to register the energy flows from the small power producer. Meter M2 ...directional and thus registers the net energy production (or consumption) of the ...ner's facility. (Note that some types of small power producing facilities consume ... amounts of energy from the utility during their quiescent, start-up and shut-down ...s.)

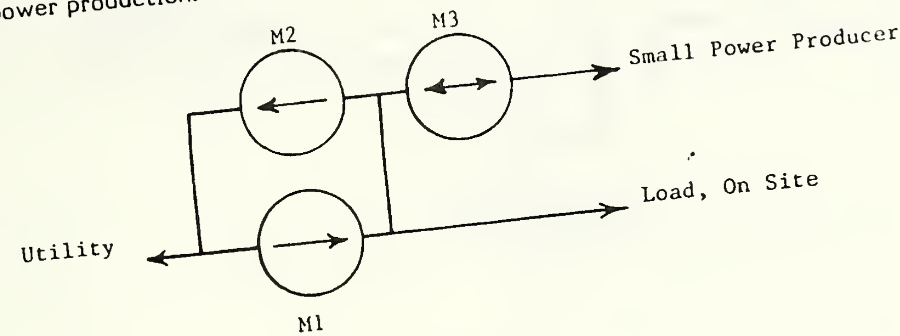


Characteristics

1. An additional meter and socket must be provided.
2. An extra meter must be read and billing procedures adjusted accordingly.
3. Information is provided regarding the on-site load and the net facility energy production. No information on coincidence is provided.
4. Coincidence is not a relevant factor to the customer except as it affects the purchase rate.
5. Different purchase and sale rates may be applied.

Metering System D (Monodirectional--Three Meters)

System configuration D is similar to system B with an important difference. The additional third meter (M3) provides data on the net power generation and enables calculation of the coincidence of the facilities' generation to on-site load. Such an arrangement provides a considerable amount of information. If the on-site load profile is known, the coincidence factor may be a useful determinant of the tariff rates. For example, power production of member-owned systems may be coincident with utility system and on-site consumption hours. Thus, sales and purchases (meters M1 and M2, respectively) could be weighted toward off-peak hours implying off peak rates. Or, on-site loads may not be coincident with either the customer's generation or utility system peak load hours. In this case, off-peak sale rates and on-peak purchase rates are implied. This type of flexibility is useful for the purpose of tailoring tariffs to different types of small power production.

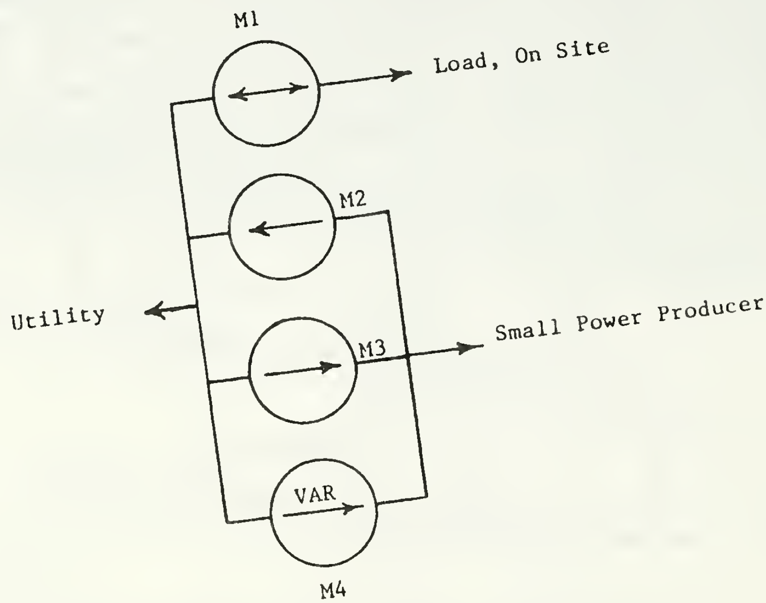


Characteristics

1. Two extra meters and sockets must be provided.
2. Two of the three meters must be monodirectional.
3. Three meters must be read, a simple coincidence calculation performed (C=1-(M2/M3) and billing procedures adjusted accordingly.
4. Information is provided on net facility energy production, coincidence, and cumulative total energy purchases and sales.
5. Coincident power production offsets purchases from the utility at the retail rate. Non-coincident and excess production may be purchased by the utility at a different rate.

Metering System E (Three-phase systems only.)

This configuration is a variation of system C. Meters M2 and M3 differentiate between energy consumption and production of the customer's generation. The reactive power meter M4 measures the reactive power consumed by the power facility. (This meter may be appropriate for some technologies which consume reactive power such as induction generators and some synchronous inverters.) In other respects refer to system C.

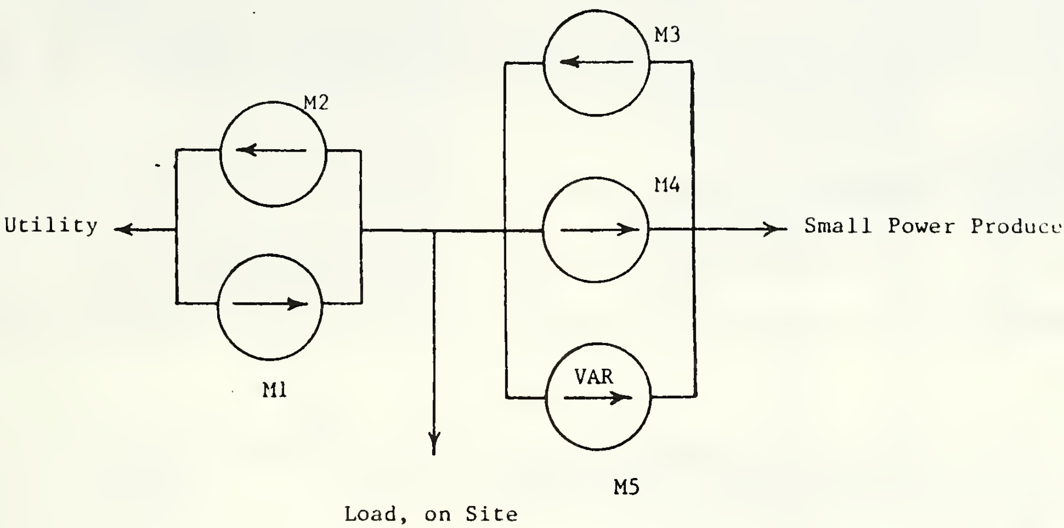


Characteristics

1. Three additional meters and sockets are required.
2. Four meters must be read and billing procedures adjusted accordingly.
3. Information is provided on the facilities' reactive and real power consumption in addition to generation.

Metering System F (Three-phase systems only.)

This metering system is an expansion of configuration D. In addition to the comments on system D, this system provides more information on the operation of the power facility. The VAR meter (M5) registers the reactive power consumption of the facility and meters M3 and M4 provide discrete data on facilities' consumption and generation.



Characteristics

1. Requires four additional meters and sockets.
2. All four kWh meters are monodirectional.
3. Five meters must be read and billing procedures adjusted accordingly.
4. This configuration provides more information on electrical parameters than the other systems illustrated.

EXHIBIT E

This is a four jet vertical turbine with 2 7/16 inch ground and polished stressproof steel shaft, Timken bearings, ½" steel weldment housing, water seal labyrinth type slingers, four steel plate side inspection covers on housing. Jets 1 5/8 to 1 7/8 in, all jets fed by 6" flanged feeders with butterfly valves (hand operated),all feeders manifolded to a common feeder. It has a 304 stainless steel 20 cup runner, 9.75 pitch dia. There are 4 jet deflectors linked together to a common trip weight to be held open by a simple electric soleniod.

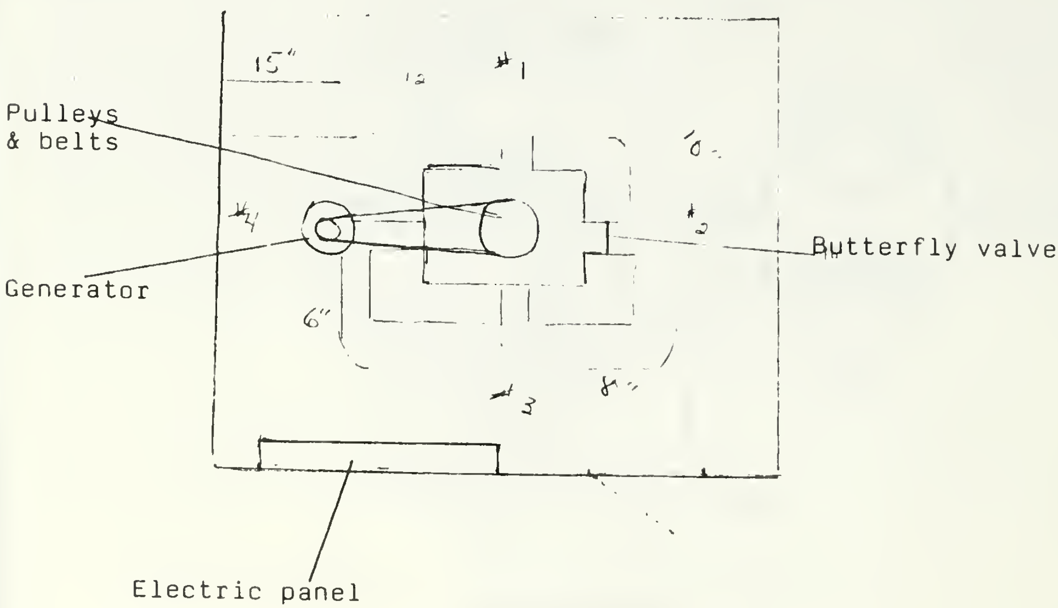


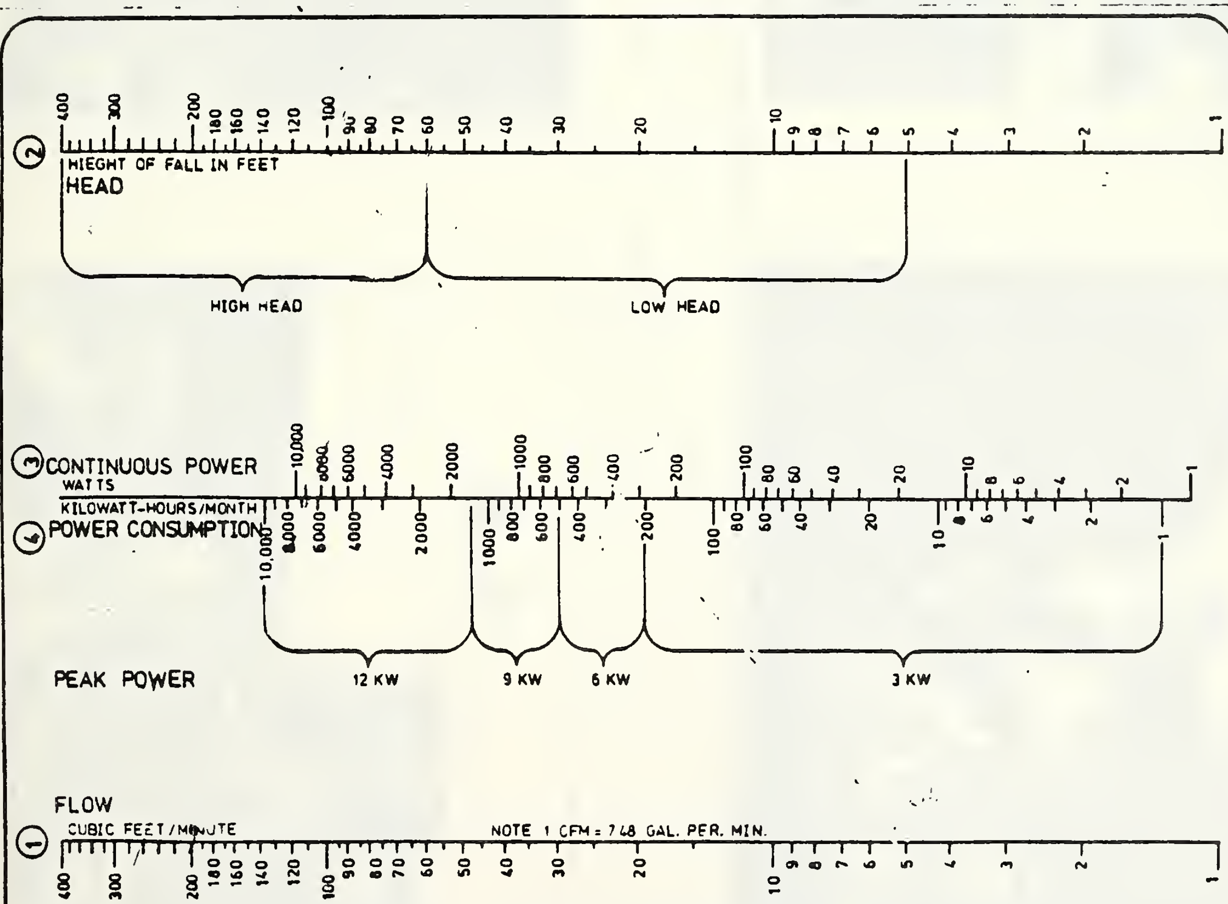
EXHIBIT F

Charting your electical output

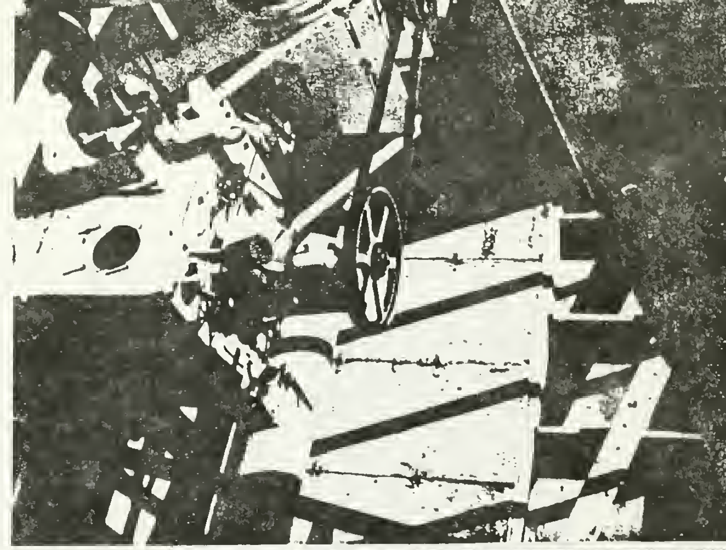
NOMOGRAPH

To use the nomograph:

1. Locate your flow on the scale (1).
2. Locate your head value on the scale (2).
3. Using a ruler, draw a straight line through these 2 values.
4. Your continuous power output appears where the line intersects scale (3).
5. Scale 4 gives the equivalent total power consumption per month in KW hr./mo. you may expect.
6. The peak power output of the system is shown by the brackets

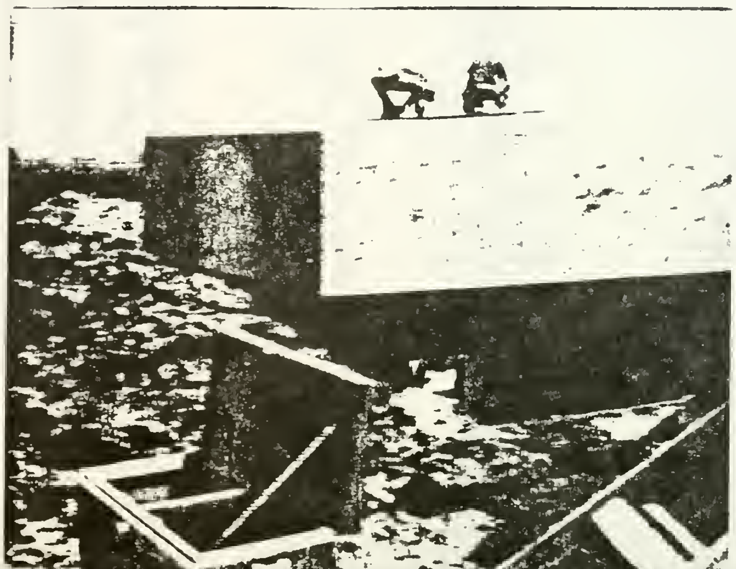


HYDROELECTRIC POWER CONVERSION NOMOGRAPH



[illegible] of 1520 ft pipeline
[illegible] NE) [illegible] being constructed

4 jet pelton setting in station
[illegible]



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